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Travellers' attitudes towards Park-and-Ride (PnR) and choice of PnR station: Evidence from Perth, Western Australia

Doina Olaru[a]*, Brett Smith[a], Jianhong (Cecilia) Xia[b], Ting (Grace) Lin[b]

[a]*The University of Western Australia, 35 Stirling Hwy., Crawley, 6009, Western Australia, Australia*
[b]*Curtin University, Bentley, Western Australia, Australia*

Abstract

An attractive transport alternative that combines the efficiency of public transport with the flexibility of cars, with the potential to reduce traffic congestion and become integral part of the transit-oriented developments, PnR received much interest in the last decade. This is particularly relevant to Australian urban landscape and especially Perth, where the low urban density means that more than 90% of residents live outside of 800 m distance from train stations.
Drawing on an intercept survey, we identified PnR and basic facilities within the station perimeter as key differentiating factors of access and service across rail corridors. Then, using discrete choice models we found that paid parking bays, bike lockers, access mode and time-of-day were the most influential in determining the choice of train station, more so than the distance. Notably, there were two classes of travellers, one seeking stations with good facilities, and the other being more interested in quick access to the station.

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Keywords: Park-and-Ride (PnR), Train station choice, Attitudes towards PnR

1. Introduction

Park-and-ride (PnR) provides residents of low-density suburbs or at the urban fringe with a fast and flexible access mode and reduces congestion on arterial roads (Holguin-Veras, Reilly, & Aros-Vera, 2012). For this reason, interest in the use of park-and-ride (PnR) has surged in recent

* Corresponding author. Tel.: +61-08-64883908; fax: +61-08-64881005. *E-mail address:* doina.olaru@uwa.edu.au.

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years. The principle of the system is to enable commuters to make part of a journey (usually to a central location) by train, saving on higher parking costs at the destination and avoiding congested roads. For suburban residents, PnR means that their journey to and from the railway station is not constrained by the infrequent timetable of local buses (Parkhurst, 2000; Hamid, 2009; Holguin-Veras, Reilly, & Aros-Vera, 2012), which also benefits commuters who would otherwise use public transport for their entire trip (Karamychev & van Reeven, 2011; Duncan & Christensen, 2013).

In Australia, PnR has become part of the urban landscape, especially in relation to TOD (Olaru, Smith, & Taplin, 2011). The relative low-density of the suburban areas where facilities are added help explain the PnR's fast rise (Duncan & Christensen, 2013). In high-density settings such as Kuala Lumpur, PnR facilities are built on a smaller scale and appear to have a lower utilisation (Hamid, 2009). These findings are consistent with PnR being a multi-modal transport option that allows flexible and fast access to major rapid transport nodes located in poorly serviced suburban settings.

Ideally, a PnR system would be one with a clearly defined catchment around each station. Travellers, and primarily commuters, would access their nearest station by car, park, and ride. However, the flexibility of the car means that drivers can speed up their entire journey by accessing stations that are further along their route. In addition, commuters can move backward along the line to avoid entering a crowded service or they may switch lines to gain access to a greater provision of parking. These decisions are highly influenced by the departure time choice: early departures are not subject to the congestion of the roads (allowing travelling further by car), not affected about crowding (back peddling to a station close to the end of line) or finding parking spaces (searching for stations that are more likely to have remaining free parking bays).

The paper reports the access mode behaviour of 945 Perth travellers. The intercept survey ran on two adjacent days at seven selected stations. Along with recording the details of their trip, the survey asked respondents to state the importance of 12 station facilities and rate them at the station. In addition, travellers were asked to provide a qualitative response on why they choose PnR. A binary choice model was used to capture the associations between the attributes of the railway station, the characteristics of the individual and whether they chose their nearest station.

The paper opens with a review of the literature on the factors affecting the use of PnR systems (Section 2). This is followed by a description of the data collection (evaluation from an intercept survey) in Section 3. The associations between railway station facilities, level of ridership, as well as the attitudes and perceptions of travellers about PnR are presented in Section 4 and the paper concludes with comments on limitations and implications for research and practice.

2. Park-and-Ride Systems

2.1. Benefits and Challenges

Increased ridership due to PnR is associated with lower congestion, increased revenues for public transport services, or reduced costs for local feeder bus services (Karamycev & van Reeven, 2011). Yet, PnR areas use substantial space near stations where compact development could take place, they discourage walking, attract noise, traffic and may be visually unappealing. Olaru, Smith, & Xia (2013) found that a significant negative association between the mix of uses around station and the number of secure parking bays, highlighting the competition for land between TODs at the intermodal point and the parking facilities.

Whilst PnR offers an efficient alternative to accessing major transport nodes in low-density settings, it can act as a detractor for building medium density mixed land-use settlements around these stations (Cervero, 2005; Kim, Ulfarsson, & Hennessy, 2007; Curtis, 2008). The idea of transit-oriented design, TOD, has at its core the notion that each node has a mix of attractions (retail, service and other facilities) along with residential lots. A high-medium density of residential lots means that walk and cycle access to the major transport node is possible for a good proportion of the TOD catchment zone and well-routed feeder buses could service the outer regions of the zone. Any PnR provision would be small. However, it is unclear that such designs would be able to produce the level of ridership offered by stations with a high provision of PnR bays (Duncan, 2010). It is only through PnR that the rapid mass transport is feasible in the outer suburban areas (Meek, 2008; Martinovich, 2008). Another challenging aspect is that PnR offers incentives to the public transport users to use cars for a part of their journey (Karamychev & van Reeven, 2011). Thus PnR may not actually reduce the level of congestion if the train trip is shorter than the car access trip (Parkhurst, 2000). In the same line of thought, AASHTO (2004) criticised locating PnR facilities at mixed-use destinations.

2.2. Factors affecting the use of PnR

2.2.1. Departure time and road congestion

Despite increases in PnR provision, generally commuters need to arrive at the railway station early in the morning to secure a parking bay. In the San Francisco Bay area 56% of the commuters depart between 4:00am and 6:00am in order to find PnR spaces at stations on corridor I-80 (Shirgaokar & Deakin, 2005). In Perth many stations start to fill before 6:00am and have no more available parking bays by 7:30am (Martinovich, 2008). Departure time is critical to the choice of travel mode and, in the case of PnR, of the station and access mode. Also, congestion is not uniform during the day and adjusting departure time is a way to avoid high generalised costs at peak hours.

2.2.2. Access mode

Access time and cost significantly affect the choice of travel mode and station (Hole, 2004; Polydoropoulou & Ben-Akiva, 2011). It is expected that greater connectivity of the public transport, friendlier bicycle and walking tracks will positively affect the choice of travel mode to the train station. For walking, distance is important and significant in access mode choice. Debrezion (2009) found that commuters are reluctant to walk to the rail station if the distance is >1.1 km. Parking cost has been consistently found significant, while parking search time, security and amenity of PnR have some weak influence on travellers (Shiftan, Ben-Akiva, Proussaloglou, de Jong, Popuri, Kasturirangan, & Bekhor, 2003; Hensher & Rose, 2007; Polydoropoulou & Ben-Akiva, 2011).

2.2.3. Station facilities

Characteristics of railway stations play an important role in station choice decisions, as evidenced by Debrezion, Pels, & Rietveld (2009) and Givoni & Rietveld (2007). Stations with better accessibility (e.g., intermodal connectivity, train frequency, and service quality) are more likely to be chosen as a travel alternative. Land-use diversity is also expected to affect the station choice (Badoe & Miller, 2000; Brons, Givoni, & Rietveld, 2007). As the objective of PnR is to encourage the model shift to high occupancy vehicles such as trains, the presence of adequate transfer facilities is a catalyst for the success of the system. Overcrowded PnR and ad-hoc parking (on street, illegal) may deter travellers in joining the train service. Similarly, limited bike facilities, unprotected against weather and theft, are unlikely to increase transit patronage as bike-and-ride system (Martens, 2007).

2.2.4. Socio-demographics and attitudes towards PnR

Nortlund & Westin (2013) found that values, beliefs and age can influence train use intention. Younger people have stronger intention to use railway than other age groups. Commuters with higher income prefer to drive rather than use public transport (De Jong, Daly, Pieters, Vellay, & Hofman, 2003; Hensher & Rose, 2007; Hensher, 2008). Women are more likely to use the car as main transport mode, whereas men prefer public transport (Bhatta & Larsen, 2011). Hensher & Rose (2007) found that men prefer public transport for work, but use the car for non-work trips. Middle-aged commuters are inclined to drive more, because of their family obligations, whereas financial and mobility restrictions cause the elderly and young to use more public transport or share driving (Bhatta & Larsen, 2011; Shiftan, Ben-Akiva, Proussaloglou, de Jong, Popuri, Kasturirangan, & Bekhor, 2003; Hensher & King, 2001).

2.3. The Provision of PnR in Perth

The development of PnR in Perth is a pragmatic solution to low densities (Olaru, Smith, & Taplin, 2011; Olaru, Smith, & Xia, 2013). More than 17,500 PnR bays are located at 55 (out of 70) railway stations, along five rail lines (Curtis, 2008; Martinovich, 2008). The majority were built at the newly constructed stations along the North-South spine of the city. These corridors have stations spaced much farther apart than the traditional East-West lines and have ample PnR supply. Currently, the limited parking spaces are occupied on a first-come basis, with a spillover from free parking to pay parking at the slight charge of $2 per day. In general, the parking areas are full by 7:30am and the cars occupy the bays until 4:30-5:00pm.

In order to meet rapidly growing public transport needs over the next 20 years, a fund of some $2.9 billion has been budgeted for infrastructure upgrades, of which $135 million will be used to improve transit interchanges such as PnR facilities (PTA, 2011). However, the high construction cost of each bay (about $20,000 AUD) means that the government needs to re-assess the location and charges for new parking areas, the required service supply, and the latent commuter demand.

3. The Use on PnR in Perth

This paper reports findings from a survey of preferences for PnR features and travel, conducted at a sample of seven train stations in Perth, Western Australia.

Perth benefits from a radial network of more than 173 km, with five corridors and one spur line, including 70 stations, built at various stages (Figure 1).

The East-West corridors (Fremantle and Midland) were built more than a century ago. The Northern corridor, Clarkson, has been operating from middle 80’s and the Southern line, Mandurah, is the latest addition to the network (operating since 2007). The corridors traverse areas with distinct urban features. The Clarkson-Mandurah spine is primarily a PnR and bus interchange system, running mainly on the median strip of the Mitchell and Kwinana Freeways. Several stations have up to 1,000 parking bays. The Fremantle line (West) goes through well-established affluent suburbs, many along the Indian Ocean coastal line, with mixed land use around the stations and little PnR (in average 30 bays/station). The Midland and Armadale corridors (East) are somewhere in between, with some transit interchanges, some commercial areas around train stations, and PnR limited to 500 bays (in average only 120 bays).

The survey was conducted on the 31st of July and 1st of August 2012, on the platforms, interviewing travellers before they were boarding their trains. The survey included questions related to the access mode to the train station, origin and destination of the trip, motivation for choosing the train station, as well as a number of attitudinal questions aimed at understanding what facilities and services are important for riders and how they view their quality at the selected train station.

Fig. 1.Rail network and surveyed stations at the five corridors (from left, clockwise: Fremantle, Clarkson, Midland, Armadale, and Mandurah)

4. Methods and Results

Two modelling approaches were applied sequentially in this research: factor analysis of attitudinal data and discrete choice modelling of a binary choice for the closest train station (or otherwise) to the traveller's departure location. By using factor analysis we created composites, reflecting the importance the public placed on various facilities at the train stations and around them and the perception about their quality. These composites were then tested into discrete choice models as covariates affecting the choice of a boarding station. These models are presented in Section 4.3.

4.1. Descriptive statistics

Across the sample, the dominant access modes were PnR and bus (in equal proportions), followed by walking and Kiss-and-Ride (KnR), with mode split differences by station. Two thirds of the trips were for commuting or education and 9% for personal business. Sixty-two percent of the respondents had as destination Perth CBD and the suburbs nearby it.

When asked about their main motivation to choose PnR, the respondents indicated advantages such as: convenience (33%), low cost (26%), and speed (20%).

Table 1. Mode split for access to the train station (945 respondents)

Access mode	Travel mode - Survey day (%)	Regular travel mode (%)
Car (driver)/PnR	29.8	28.6
Car (passenger)/KnR	19.7	13.1
Bus	27.1	30.6
Walk	18.9	19.2
Bike	1.2	2.5
Other	3.2	5.9

Qualitative answers to an open-ended question showed that Perth travellers enjoy the presence of PnR at train stations as a possibility to have a wider choice set, not "forcing them out" of their cars. Importantly, if parking were not available at the station, half of the PnR travellers would continue driving to the next station or to the destination and 37% would return home, changing their travel plans.

4.2. Results factor analysis

Factor analysis confirmed three uni-dimensional constructs of transport facilities, based on their importance allocated by respondents: *parking and bike facilities* (free and secure, locked and paid parking, bike storage), *basic facilities* within the station perimeter (public utilities, disabilities access, information), and *seating and retail/food* establishments. A similar structure was confirmed for the rating provided by respondents on the facilities available at the train station (Table 2). Within *'Basic facilities'*, the key elements (highest loadings) were frequency of services, lighting, access, and personnel, quite distinct from information and emergency services, expected to be present at the stations and without much variation between stations. The *'Parking and bike facilities'* were dominated by the number of locked/paid parking bays, and the *'Seating and retail establishments'* by seating on the platform and train (crowding).

Table 2. Structure of the latent constructs

Importance facilities		Construct	Items	Rating facilities	
GOF and variance	Loadings			GOF and variance	Loadings
X^2 = 8.08 (9); p=0.526	**0.882**	Basic facilities	Lighting	X^2 = 15.507 (9); p=0.078	**0.896**
Var = 0.547	**0.832**		Staff	Var = 0.472	**0.810**
	0.529		Information		0.668
	0.791		Emergency services		0.695
	0.869		Easy access to platforms		**0.859**
	0.909		Frequency services		**0.916**
X^2 = 0.000 (0)	**0.790**	Parking and bike facilities	Free PnR	X^2 = 0.000 (0)	**0.794**
Var = 0.659	**0.986**		Locked PnR	Var = 0.679	**0.983**
	0.604		Locked bike storage		0.701
X^2 = 0.000 (0)	**0.838**	Seating and retail/food establishments	Seating on the train	X^2 = 0.000 (0)	**0.882**
Var = 0.603	**0.953**		Seating on the platform	Var = 0.516	**0.921**
	0.590		Shops/food outlets		0.762

4.3. Results binary choice model

When investigating the access to the train stations, we found substantial variability in the catchment areas around the stations by mode and also, that riders do not travel to the closest stations to their residences. In fact 40% of them boarded trains at stations further away from their departure location. Table 3 summarises the distances by main access modes and stations. As expected, these distances were highly correlated with the Euclidean distances for walking and cycling, but not for the motorised access modes. The average distance to the boarding station is about 6.07 km, considerably longer than the distance to the closest train station (3.68 km), one of the reasons being that stations vary in the presence and quality of the facilities they offer.

Table 3. Distance to access the train station (km)

Access mode	Travel distance to the train station (mean, std.dev)						
	Claremont (Fremantle)	Greenwood (Clarkson)	Warwick (Clarkson)	Midland (Midland)	Cannington (Armadale)	Murdoch (Mandurah)	Warnbro (Mandurah)
Car (driver)/PnR	3.85 (4.29)	3.97 (3.00)	4.39 (4.17)	9.65 (6.60)	6.50 (5.96)	7.44 (6.55)	8.54 (9.75)
Car (passenger)/KnR	3.41 (3.24)	5.97 (6.04)	5.43 (5.79)	10.77 (7.69)	6.99 (7.17)	5.38 (5.69)	6.01 (6.52)
Bus	6.87 (6.17)	7.40 (1.46)	5.41 (5.66)	8.42 (5.56)	4.64 (3.11)	6.47 (6.16)	5.44 (6.22)
Walk	1.30 (1.09)	1.81 (1.40)	3.83 (2.20)	3.62 (2.61)	2.48 (1.19)	1.95 (1.94)	1.57 (0.86)
Bike	4.03 (4.29)	3.12 (2.95)	N/A	N/A	5.05 (6.22)	2.41 (0.70)	N/A

Two types of choice models were then estimated on the choice of station (the closest to home or the second nearest station towards traveller's destination), with results compared in Table 4.

Table 4. Multinomial Logic (MNL) and Latent Class Model (LCM) for station choice (Parameter estimates and t-statistic)

Explanatory variables and model fit	MNL1 N=930	MNL2	MNL3 (interact with depart time)	LCM1		LCM2	
				Class 1 N=511	Class 2 N=419	Class 1 N=418	Class 2 N=512
Distance to the station (km)	0.014 (1.16)	0.014 (1.17)	0.014 (2.27)	**1.035 (3.49)**	**-0.665 (-2.67)**	-0.037 (-0.65)	-0.302 (-1.42)
Land-use (latent score)*	**0.361 (3.62)**	**0.354 (3.34)**	**0.367 (3.66)**	**8.302 (3.51)**	**-2.846 (-2.97)**	**9.421 (3.40)**	**-41.265 (-2.24)**
Basic station facilities (latent score)	**0.555 (5.94)**	**0.543 (5.62)**	**0.545 (5.80)**	**4.956 (3.53)**	0.654 (1.18)	**2.910 (2.70)**	1.059 (0.78)
Number free PnR bays	**-0.004 (-8.38)**	**-0.004 (-7.66)**	**-0.041 (-8.26)**	**0.139 (3.26)**	**-0.092 (-2.95)**	0.003 (1.30)	**-0.179 (-2.25)**
Number locked (paid) PnR	**0.008 (8.94)**	**0.008 (8.49)**	**0.008 (9.10)**	**0.132 (3.48)**	**-0.022 (-2.13)**	**0.038 (4.54)**	-0.020 (-1.21)
Number bike lockers	**-0.075 (-6.04)**	**-0.078 (-6.08)**	**-0.073 (-5.98)**	**0.911 (2.89)**	**-0.934 (-3.19)**	**-0.423 (-3.17)**	0.178 (0.49)
Car (driver)/PnR access	0.079 (0.49)	0.133 (0.73)					
Car (passenger)/KnR access	0.060 (0.29)	0.198 (0.84)					
Feeder bus access	-0.021 (-0.12)	0.196 (0.87)					
Walk access	**0.451 (2.33)**	**0.612 (2.58)**					
Bike access	-0.025 (-0.04)	0.139 (0.21)					
Departure time		**-0.182 (-2.13)**				**-0.207 (-2.38)**	
LL	-504.106	-500.169	-502.482	-429.896		-413.316	
AIC/N	1.098	1.094	1.101	0.998		0.921	
Pseudo R^2	0.164	0.192	0.191	0.308		0.348	

Note: * For derivation of this factor including shops, restaurants, and offices, please see Olaru *et al.* (2013).

The model predictors include two types of factors anticipated to influence the choice of boarding station: factors related to the accessibility and to the rail services provided at the station (as in Debrezion, Pels, & Rietveld, 2009). Whereas facilities appeared to increase the attractiveness of a station, the distance to the station was not an important element in deciding where to get on the train. With the exception of one latent class (LCM1), the parameter estimate was not statistically significant and the sign seems to indicate that travellers do not choose the nearest station. This is consistent with Debrezion, Pels, & Rietveld (2009), who proposed a rail service quality index to overcome the limitation of using distance to the railway station as a measurement of accessibility.

Although frequency of service and position in the network or connectivity did not have a significant part in station choice in our case (perhaps because of the homogeneity of urban services in Perth and the network structure), the provision of PnR bays (especially paid), the quality of other facilities at the train stations, and the land-use around the stations played a more prominent role across all models.

As expected, those accessing the station by foot and those departing early in the morning are more likely to board the train at the closest train station, as confirmed by the significant coefficients in the models. Notably, the number of bike lockers has a negative sign, suggesting an uneven quality of bike lockers at some stations (e.g., Armadale line), which require patrons to choose other boarding stations that offer the required facilities. We also need to indicate that in Perth bicycles cannot be taken on train services during peak hours and there are no bike-hire services at the train stations.

Of interest is the distinction between the latent classes in the two models (Table 5), including or not the departure time.

Table 5. Profile of latent classes LCM1 and LCM2 (Only differences significant at 0.05 level **)

Characteristic	LCM1		LCM2	
(%)	Class 1 (Facilities)	Class 2 (Distance)	Class 1 (Facilities)	Class 2 (Distance)
Senior	11.1	15.2**	12.4	12.8
Middle age group	47.7**	25.3	36.2	38.3
Fremantle	21.4**	4.4	20.0**	5.1
Armadale	17.1**	10.3	7.4	20.5**
Mandurah	38.7**	22.8	26.7	34.5
PnR access	27.0	34.1**	33.9**	26.2
Bus access	38.9**	13.0	21.3	32.0**
Walk access	10.1	29.6**	20.9	17.5
d closest station (km)	8.37	7.91	7.81	8.20

Class 1 travellers seek stations with good facilities and secure PnR, whereas class 2 are more sensitive to the distance to the station. In LCM2, travellers who depart earlier from home are more likely to be associated with class 1. In the model without the time of day, class 1 *("Facilities")* is associated with stations from South and East-West corridors (Fremantle, Armadale and Mandurah), higher access by bus corridors and higher proportion of middle age riders. Senior travellers, accessing stations by PnR and walking and from the Midland corridor are more likely to be part of class 2. The model accounting for the departure time, shows different features for the two classes: class 1 has significantly more travellers from the West corridor (Fremantle), accessing the stations by car and thus departing station earlier, whereas class 2 has more travellers from Armadale and accessing the station by bus.

5. Findings

The provision of PnR facilities has been identified as a vital facility used by train riders in Perth. This is because of the reduced population and employment densities in our city, which means that most train stations in Perth are accessed by car and to a lesser extent by feeder buses, walking, or cycling. Basic facilities at the stations are also important and they are dominated by train headway, easy access to the platform, followed by lighting and presence of staff.

In regard to the station choice, quality of facilities at stations and land-use were significant predictors and only 60% of the travellers boarded at the nearest station. The access distance was relevant for the choice of boarding stations only for walking and/or for the pre-morning peak departure time. This implies that shorter distances are used when access is not affected by congestion or constrained public transport facilities such as PnR. The availability of parking bays, especially locked/paid bays has a positive effect on the choice of stations, whereas bicycle lockers appear to have a negative effect. The latter suggests that cyclists need to ride on longer routes to find stations with quality facilities. Yet, this aspect needs to be investigated further, as the sample size of bike-and-ride travellers was insufficient in this occasion. Although feeder buses were expected to have a positive effect, the lack of statistical significance is explained by the negative effect of the coverage and frequency of services, as well as of the congestion conditions that affect their access to the train station.

The results have planning implications: analysis of the socio-economic fabric and land-use around all stations, gives indications of the residents' employment and flexibility of work start time (which in turn affects their departure time) and also gauge preferences for transport facilities. Then the supply of PnR, bus-and-ride, and bike-and-ride may be adjusted accordingly: stations closer to the city, in higher density areas do not require PnR, but pedestrian friendly access, whereas stations towards the fringes and with poor public transport services should be given PnR priority. Of particular interest if the finding that Perth travellers prefer secure/paid parking bays at the railway stations over free PnR supply. Finally, good quality train facilities and the land-use around stations have a positive influence on the choice of where to board the train. Qualitative comments made by respondents confirmed the finding.

In terms of limitations and further research, our models assume the choice of station only between two stations (closest and following station on the corridor towards traveller's destination). Additional work could be undertaken by including in the choice set other feasible stations (further from the destination or on other corridors). Also, we assumed here that the traveller decided the access mode before boarding the train. It is well documented that order of the decisions – mode and departure time – will have an effect on modelling the changes in travelling costs by different modes and at different times (Daly, Hess, Polak, & Hayman, 2009). We acknowledge that this decision is likely to be made jointly, but the sample size limited us to explore this avenue.

Traffic congestion may substantially affect the choice of train station. At peak times, drivers may prefer a station they can reach quicker and has sufficient provision of PnR, even if it's not the 'closest'. The effect of the congestion has not been directly taken into account, because of data availability, however it is expected this would be significant for station choice.

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